Technical Report No. LWL-CR-09E71

Public Address Set
AN/UIQ-10 (XLW-1)

Final Report

Work Assignment
Number 4

Contract DAAD05-70-C-0252

Bendix Field Engineering Corporation
9250 Route 108
Columbia, Maryland 21043

Approved for public release; distribution unlimited

U. S. ARMY LAND WARFARE LABORATORY

Aberdeen Proving Ground, Maryland 21005

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ABSTRACT

This report covers the development of the Public Address Set AN/UIQ-10(XLW-1) under Contract DAAD05-70-C-0252 with the Bendix Field Engineering Corporation. The report also describes the functioning, the characteristics, and the outcome of the various tests performed on the equipment after its development.

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1. INTRODUCTION

Work Assignment Number 4 under Contract DAAD05-70-C-0252 with U. S. Army Land Warfare Laboratory was accepted by Bendix on 10 February 1971. The task involved development of Public Address Set AN/UIQ-10 to meet the joint requirements of the Army, Marine Corps, and Air Force for a man-packable public address set. Original concept definition was begun by Land Warfare Laboratory when a prototype model of the AN/UIQ-8 Public Address Set developed by the Marine Corps was reconfigured and operationally field-tested. The work was then extended through an engineering study under Work Assignment No. 3 of Contract DAAD05-70-C-0252.

As a result of the preliminary efforts described, the statement of work for Work Assignment No. 4 established the basic system concept for Public Address Set AN/UIQ-10 which remained stable throughout the development, even though many details were subject to modification and elaboration.

2. CONDUCT OF ASSIGNMENT

The work done on the AN/UIQ-10 can be divided into a number of phases for discussion purposes, although in practice there was considerable merging and overlap of these phases. The dominant factor throughout the task was the urgency of producing the prototype hardware in a limited period of time, to permit concept verification and approval by the several military services concerned.

2.1 System Development. The work statement required the AN/UIQ-10 to be a refinement of the AN/UIQ-8 as reconfigured by Land Warfare Laboratory. One unit consists of the amplifier unit, one trumpet driver, a standard ECOM battery, the remote control unit and a microphone, all mounted on a rucksack frame. The second unit comprises three trumpet drivers mounted on a rucksack frame, to be paralleled with the basic unit when more audio power is needed. The electronic circuitry of the AN/UIQ-8 was to be used intact except for minor improvements, such as addition of alarm generators. These constraints pretty well define the basic system design, leaving the physical or mechanical design as the major area of effort.

2.2 Prototype Mock-up. A cardboard and wood mock-up of the system was constructed to illustrate the Bendix design concept. This was inspected by Service representatives on 17 February and 2 March 1971 and numerous comments and suggestions made for improvements. Although some aspects of the system design continued to evolve, the basic design of the two most important components, the amplifier unit and the control unit, was accepted on the basis of the mock-up.

2.3 Mechanical Design. The primary difference between the AN/UIQ-10 and the predecessor AN/UIQ-8 system, other than the system reconfiguration, lies in the mechanical design of the major components.

2.3.1 Amplifier Unit. The redesign of the amplifier had to be based on the requirement that the standard ECOM battery plugs directly into an interface on the bottom surface. Two dimensions were thus set by the battery interface dimensions. The height of the amplifier package was determined by the input and output connectors and binding posts required. The need to keep overall width to a minimum while protecting the connectors from physical damage caused the amplifier case to have a distinctive "hour glass" shape. The main circuit board was hinged to provide access for maintenance without requiring extension cables for operation during servicing.

2.3.2 Control Unit. The remote control unit was completely redesigned for better human engineering practice. When mounted on the belt, all controls and indicators face upwards in full view of the operator. Input connections are located on one edge of the unit, output connections on the other. Protruding flanges guard the external components from damage.

2.3.3 Back-pack Frames. The back-packs are based on a mounting plate to which the various system components are attached. The plates are secured to a standard military rucksack frame. A good deal of consideration was given to the arrangement of the supporting legs, with many possible configurations explored, before returning to a refinement of the method used by Land Warfare Laboratory to reconfigure the AN/UIQ-8. Improved telescoping legs were found after consulting with ECOM personnel and following up the leads provided. Design requirements for the loudspeaker brackets continued to change even after the prototype was complete, as additional field deployment needs were made known. The final configuration includes removable brackets fastened with captive screws, this arrangement to be effective on all units made after the first prototype.

2.3.4 Drawings. Sufficient drawings were made to permit building a limited number of prototypes on an engineering basis. Even though no drawings were created solely for documentation purposes, the total number of drawings produced was approximately seventy-five; this is many more than originally contemplated on the job, due primarily to unexpected complexity of the mechanical structures.

2.4 Electrical Circuit Changes. To a large extent the circuitry of the AN/UIQ-8 was retained intact in the AN/UIQ-10. Since that equipment had successfully passed the performance and environmental tests imposed by the Marine Corps, it was felt that changes should be made only where actually required or where a definite saving could be achieved. One change was made in the power control circuit, where an entire schmitt-trigger circuit was eliminated without losing any functional performance, and where the "clock-killer" circuit was changed to make it work properly. However, all the amplification, comparison, and power switching circuits are identical to the AN/UIQ-8. It follows that system performance will be essentially identical to that of the AN/UIQ-8 system.

After completion of the first prototype, additional requirements were imposed which made necessary certain minor changes in the power control circuit. These modifications, to be incorporated in subsequent units, reduce the switch-off battery drain to negligible proportions and permit slaving of a large number of amplifiers to one control unit.

2.5 <u>Prototype Construction</u>. As soon as the mock-up was approved, design of the mechanical parts was begun and electrical parts were placed on order. Fabrication of the control unit chassis was started on 5 April 1971, the amplifier chassis on 24 May 1971, and the back-pack assemblies on 26 May 1971. The major system components were wired and tested in the laboratory by 25 June 1971.

On 13 July 1971 a field demonstration of the prototype was conducted for representatives of the Army and Marine Corps. The prototype was approved as a first model; however, a number of modifications were suggested to meet specific new requirements. The changes will be made under Contract DAAD05-71-C-0371 and are not part of Work Assignment 4.

3. PURPOSE OF EQUIPMENT.

Public Address Set, AN/UIQ-10(XLW-1) is a lightweight, high-efficiency voice amplification system, primarily intended to provide the military services with a practical man-pack public address capability in the tactical environment. The complete set is carried by two men, and provides up to 250 watts output to four horn-type speakers. One man can pack a completely functional sub-system which produces up to 65 watts output to one speaker.

The major components of the AN/UIQ-10 are also capable of applications other than the man-pack role. With different installation hardware they can be used in ground vehicular, aircraft, helicopter, and fixed-plant applications.

3.1. LIST OF EQUIPMENT SUPPLIED.

Public Address Set AN/UIQ-10(XLW-1) consists of the following items.

Quantity	Description
1	Amplifier, Audio Frequency, AM-6482(XLW-1)/UIQ-10.
1	Control, Amplifier, C-8967(XLW-1)/UIQ-10.
1	Loudspeaker, LS-608/UIQ-10.
1	Accessory Kit (microphone, control cable, radio cable, power connector; in carrying pouch).

All on Mounting Plate Assembly MT-4455(XLW-1/UIQ-10).

1	Loudspeaker Assembly, LS-611(XLW-1)/UIQ-10, three speakers.

On Mounting Plate Assembly MT-4456(XLW-1)/UIQ-10.

3.2. PHYSICAL DESCRIPTION.

The AN/UIQ-10 Public Address Set consists of two distinct man-pack units. The basic unit is a complete public address system in its own right, with output limited by the single loudspeaker with which it is equipped. The second man-pack, designated Loudspeaker Assembly LS-611(XLW-1)/UIQ-10, adds three additional speakers to permit exploitation of the full power capability of the amplifier.

Each man-pack is based on a mounting plate to which the other components are attached. Both units include the standard lightweight Army packframe, secured to the mounting plate, as the interface between the equipment and the man carrying it. These packframes permit a man to carry a heavy load in relative comfort. Both units also include a set of four telescoping legs which extend and spread to support the equipment in the operating position. The set will also accept 28V external DC power from aircraft and vehicles.

The basic system consists of the Amplifier Unit, Control Unit, one Loudspeaker LS-608/UIQ-10, and an Accessory Kit. With batteries attached, this unit weighs 35 pounds.

Loudspeaker Assembly, LS-611(XLW-1)/UIQ-10 consists of three Loudspeakers LS-608/UIQ-10 in pivoted mountings on a back-plate, with an integral cable to connect to the amplifier unit during operation. This unit weighs 31 pounds.

Amplifier, Audio Frequency, AM-6842(XLW-1)/UIQ-10 is a welded aluminum enclosure approximately 12 inches wide, 7 inches high, and 5 inches deep. The bottom surface is an interface for any one of the various Type 1 Army batteries (but not all these batteries are necessarily suitable for operating the equipment). The top surface is a finned heat-radiator to dissipate the heat produced by four power transistors. On the left side, connectors are provided for low-level signal and control interconnections; power input (other than battery) and speaker connectors are on the right side. The unit is completely closed and gasketed for immersion resistance. Access to the interior is provided through a removable cover on the back surface. Two printed circuit boards contain all except a few large chassis-mounted electrical parts. One circuit board hinges up for ease of access while still connected, or unplugs for replacement. A smaller board mounts the driver circuitry associated directly with the main power transistors; this board is semi-permanently mounted next to those transistors. The amplifier unit attaches to its mounting with four quick-disconnect fasteners.

Control, Amplifier, C-8967(XLW-1)/UIQ-10 is a welded aluminum enclosure approximately 8 inches long, 5 inches high, and 2 inches thick. It has a clip which enables it to be carried on the user's web belt in operation, and it contains all the operating controls for Public Address Set AN/UIQ-10. When it is mounted on the belt, all controls are on the top surface and visible to the operator. Microphone and other inputs face to the right hand side, while the interconnection to the amplifier unit comes off the left hand surface of the unit. Controls and connectors are guarded from accidental physical damage by protective flanges, and the control unit can be secured to the amplifier for carrying. All active circuitry is contained on a hinged printed circuit board which unplugs for replacement.

3.3. FUNCTIONAL DESCRIPTION.

The Public Address Set accepts speech input to a microphone and amplifies it to a level audible at considerable distances. Principal features are high efficiency, light weight, and the provision for man-pack portability. There are three major functional sub-divisions: the control and audio preamplifier circuits, the power amplifier circuitry, and the loudspeaker units.

a. Control and Preamplifier. This circuitry is contained in Control, Amplifier, C-8967. Inputs are accepted from an M-80/U microphone, a field telephone, a tape recorder, or a radio receiver. Two inputs can be accommodated at one time and mixed in the input circuitry. Volume control is provided, and amplification of the signal level required by the Amplifier circuit (approximately 8 volts RMS).

The alarm signals are generated in this circuit group, consisting of a continuous audio tone for the ALERT warning or a sawtooth wobbulated signal for the ATTACK warning. These are controlled by toggle switches with the ATTACK alarm having override capability.

b. Amplifier Circuits. This functional group comprises the major active circuit elements of the P.A. Set, and is contained in Amplifier, Audio Frequency, AM-6482. The audio frequency signal from the control/ preamplifier circuit is converted by means of pulse-width modulation techniques, to a high-power audio output capable of driving a low impedance load. The signal is buffered and inverted to provide two audio signals 180 degrees out of phase which are applied to the pulse-width modulator along with a clock signal at approximately 50 kHz. The modulator develops two binary trains which, when properly buffered, switch the output power transistors, which are configured in a bridge connection with a balanced output to the load. Normal full load is four loudspeakers in parallel, each 8-ohms impedance.

Power control circuits permit remote control of the system power from the control unit and provide electronic over-current and over-voltage protection, and protection against reversed polarity supply voltage.

Signal and control lines to the Amplifier circuits from the Control unit are carried in a four-conductor cable, 100 feet long.

c. Loudspeaker Units. A total of four loudspeakers are provided, any or all of which can be connected across the output power bridge to receive the balanced pulse-width modulated binary signal. The integrating effect of the loudspeaker converts the PWM signal into a replica of the original audio signal. Each loudspeaker has a power rating of 75 watts, adequate to handle the full output voltage swing produced by the amplifier unit.

3.4. ELECTRICAL CHARACTERISTICS.

Typical values for the major performance parameters of the Public Address Set are listed below. Unless otherwise indicated, all parameters are given for the standard test condition:

Ambient Temperature +25°C
Input Supply Voltage +28 volts DC
Dummy Load 2 ohms resistive
Audio Signal Frequency 1 kHz

a. Supply Voltage Range.

Nominal battery source	:	+24 volts D.C.
Nominal vehicular source	:	+28 volts D.C.
Operating range	:	+20 to +32 volts D.C.

b. Supply Current Drain. Typically 10.5 amperes D.C. at 250 watts output; approximately 600 milliamperes D.C. at no output.

c. Audio Input Sensitivity.

Microphone Inputs	: 10 millivolts RMS
Tape or Radio Input	: 100 millivolts RMS
Field Phone Input	: 100 millivolts RMS

d. Power Output. Typically 250 watts at 15% distortion.

e. Efficiency. Typically 85% at 250 watts output.

f. Distortion. Typically 15% at 250 watts output, at 450 Hz, 1000 Hz, and 3000 Hz.

g. Frequency Response. Within ± 3 dB of 1 kHz level from 450 Hz to 3000 Hz.

4. GENERAL.

This section discusses the installation of the Public Address Set. It describes the basic set which is designed for tactical, man-pack deployment in the field. The major components may also be used with special adapters (not furnished) to provide vehicular, aircraft, helicopter, or fixed-station installations if desired.

4.1. ENVIRONMENT.

The Public Address Set is designed for a broad range of environmental conditions. It will operate at temperatures from -40°C to +65°C, and in humidity up to 94% relative humidity. Since it is intended for field use under tactical conditions it is designed to withstand the effects of shock, vibration, drop, submersion, salt atmosphere, sand and dust, and rainfall when tested in accordance with appropriate sections of MIL-STD-810.

4.2. PHYSICAL INSTALLATION.

The system will normally be carried on the user's back to the site of operation, two men carrying the complete 250 watt system. When the site is reached, extend the supporting legs and set the two units in place to provide the audio coverage desired. The twist-lock telescopic legs can be individually set to any intermediate length required by uneven terrain. The legs unlock with a quarter-turn counterclockwise of the inside tube, the one with the rubber tip (CCW as viewed from the tip end). They then pull out to the desired length and lock there with a quarter-turn clockwise. The two outboard legs unsnap from the spring clips at the lower end and swing out and back to form a stable quadripod assembly.

5. SYSTEM OPERATION (See Block Diagram, Figure 5-1).

Operation of the system begins with actuation of the POWER switch in the Control Unit which activates the power control circuit located in the Amplifier. Assuming that the supply voltage and load current are not excessive, this circuit provides voltage to the other circuit elements in both Amplifier and Control Unit.

Audio inputs all go to the input circuits in the Control Unit where they are mixed together onto one signal line. Volume control is also provided in the input circuitry.

The pre-amplifier circuit provides both voltage and current amplification for the audio signal. The maximum output level is approximately 8 volts RMS. Output impedance is about 600 ohms.

Alarm signals are generated by the astable multivibrator circuit which produces a square-wave signal. When the ramp generator is energized, the frequency of the square-wave is varied by the ramp signal to produce the ATTACK alarm. When the ramp generator is not active the square-wave is a constant frequency for the ALERT signal.

The audio signal into the Amplifier Unit first passes through a simple low-pass filter (cut-off frequency 4 kHz) and then goes through two precision inverting amplifiers having unity numerical gain. They produce two buffered audio signals exactly 180 degrees out of phase with each other, which are directed to the comparator circuit.

The clock generator provides the other input to the comparator, a sawtooth waveform with a repetition rate of about 50 kHz. This is the sampling waveform which provides the time base for the pulse-width modulation.

The comparator circuit is the heart of the entire public address set because it is this circuit which converts the audio signal into a binary pulse-width modulated signal which controls the high-power output bridge. Since the audio signal is restricted in band width to about 4 kHz, its amplitude changes relatively slowly compared to the sawtooth clock waveform. To simplify the explanation of how the pulse-width modulator functions it is desirable to consider how it would function if a series of D.C. voltage levels replaced the audio signal. This concept is illustrated in Figure 5-2, where (a) shows a level, representing close to the maximum positive audio peak, superimposed on the clock waveform. The comparator output signal is shown by the binary waveform just below. The comparator output is "high" (more positive level) whenever the audio level is more positive than the clock sawtooth. In this example it is high the majority of the time.

The case which occurs when the audio level is at the mid-point is shown in (b) of the same figure. The output is now a square wave, in each state 50% of the time.

When the audio level is near the most negative peak value, as shown in (c), the binary output signal is high only for short time intervals. It is obvious that if the audio input level becomes sufficiently negative, the comparator output will stop switching and stay in the "low" state for the duration of the condition, which amounts to saturation of the modulator and corresponds to peak clipping. The same condition naturally occurs on the positive audio peaks as well.

Each of the two identical comparator circuits operates as described, but comparator B is receiving the inversion of the audio input supplied to comparator A, so the outputs will be different at any given time.

The comparators each drive one-half of the output bridge circuit in such fashion that when comparator A output is low the voltage output of that half of the bridge is high (+28 volts, approximately) and when the comparator output is high the bridge section output is low (near ground). For intervals when the input audio is above the mid-point level, the current in the load connected across the bridge will be positive and either I_{max}, where $I_{max} = \frac{V\ supply}{R\ load}$, or zero; the ratio between these two states is dependent on the instantaneous audio level. When the audio input is below the mid-point level, load current is negative and similarly switches between I_{max} and zero in proportion to the negative audio level.

One important feature of this dual-comparison modulator and balanced output bridge is the fact that for zero audio input there is essentially no net load current in either direction. One way of visualizing this effect is to realize that while both sides of the bridge are switching between the supply voltage and ground at the clock rate, they are switching "in phase" and thus there is no voltage difference across the load.

The pulse-width-modulated signal across the load is binary, with relative duration and polarity of the current the only variables. When the load is a loudspeaker coil, this switching waveform is effectively integrated by the basic low-pass nature of the load device. The sound output from the speaker is a faithful reproduction of the input audio signal.

The primary advantage of the pulse-width-modulated Public Address Set lies in the fact that the output transistors and their drivers are always either saturated or cut-off and consequently dissipation in these elements remains low under all conditions of audio output level from zero to full power. Output circuit efficiency is high across the full operating range, so that fixed losses in low-level amplifier and power control circuits become important at the lower output levels.

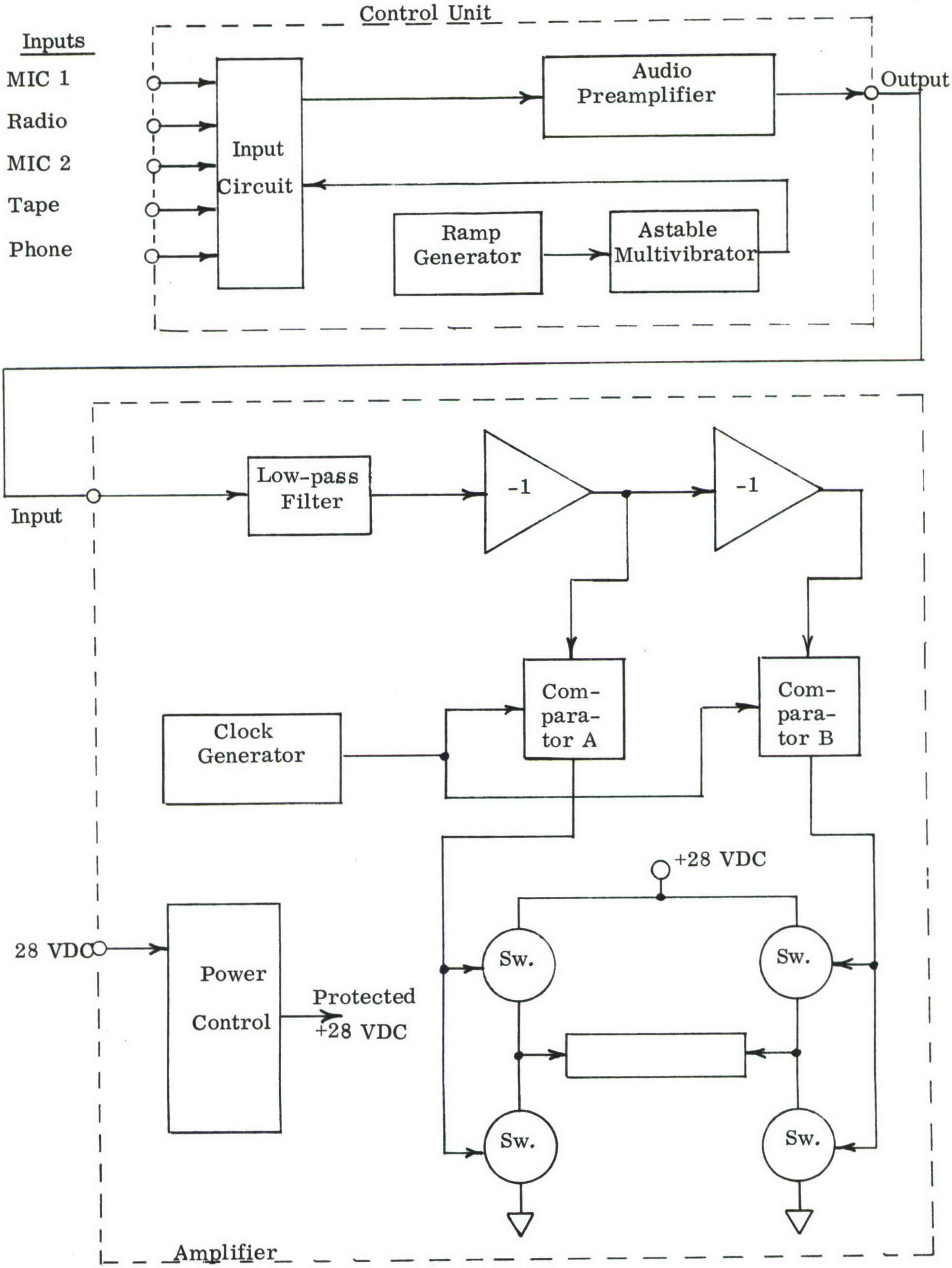

Figure 5-1. AN/UIQ-10 Simplified Block Diagram

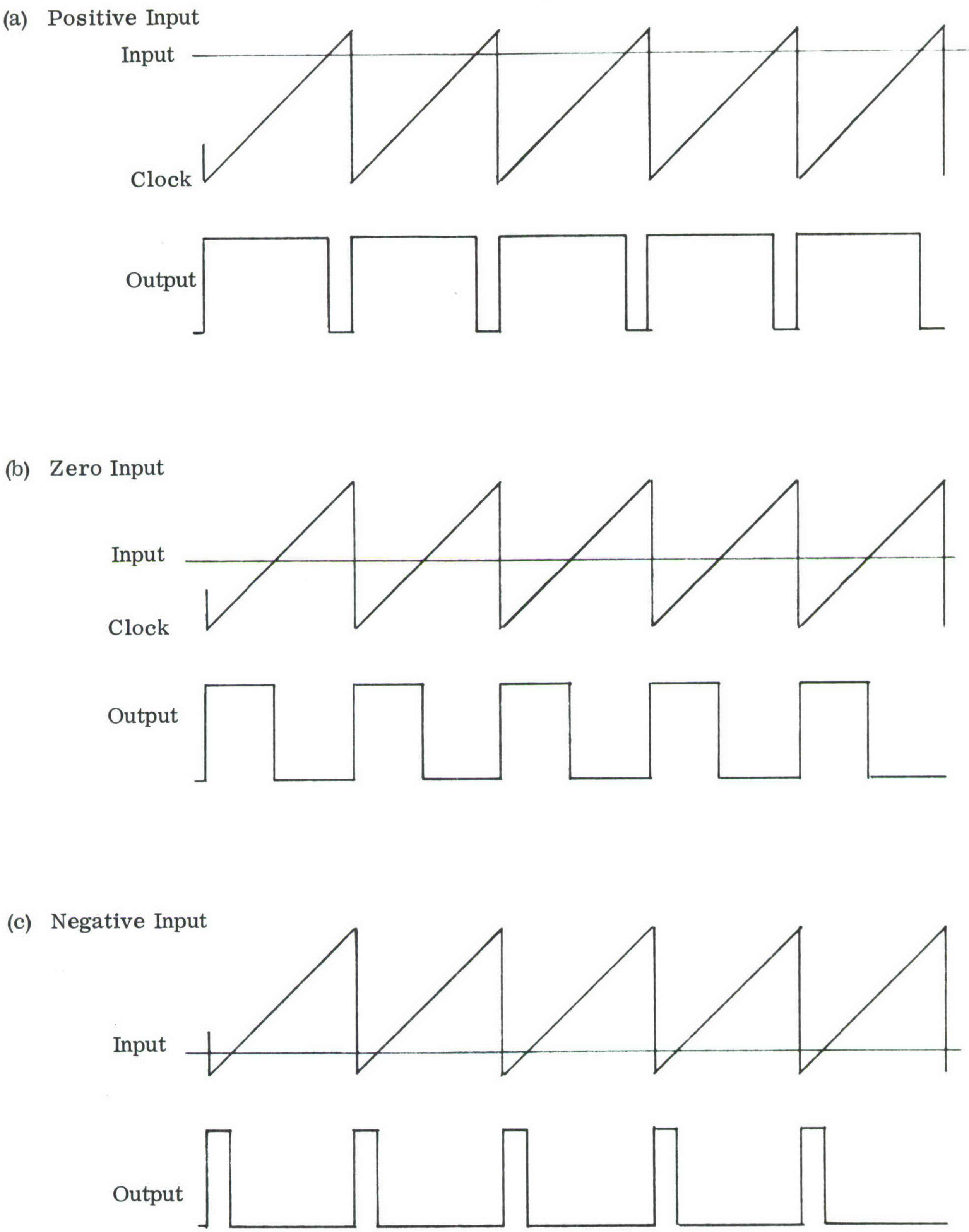

Figure 5-2. Comparator Waveforms for D.C. Input

6. <u>GENERAL</u>.

The amplifier and controller of the prototype AN/UIQ-10 (Serial #P1) Public Address System were subjected to the temperature test requirement of MIL-E-16400 for class 1 equipment as modified for the tests done on the AN/UIQ-8 as well as the vibration test required by MIL-STD-810A method 514.1 Equipment class 7. The UIQ-10 was tested for Distortion and Efficiency before, during, and after the temperature test and before and after the vibration tests.

6.1. <u>TEST PROCEDURES</u>.

6.1.1. <u>Temperature Tests</u>. The temperature test program consisted of the following steps.

a. The controller and amplifier of the AN/UIQ-10 were placed in the temperature chamber. The audio frequency generator, the power supply, the load, and the test equipment necessary to perform the distortion and efficiency tests (see Section 6.1.3) were placed outside the chamber and connected together and the electrical tests (distortion and efficiency) were performed.

b. The chamber temperature was reduced to $-40^{o}C$ and maintained for at least 24 hours. The electrical tests were performed periodically during the 24 hours and at the end of that period.

c. The temperature of the chamber was increased in steps of $10^{o}C$ (30 minutes per step) until $+65^{o}C$ was reached. The electrical tests were performed at the end of each 30 minute step.

d. The temperature was maintained at $+65^{o}C$ for four hours. The electrical tests were performed at the end of this period.

e. The temperature of the chamber was decreased in steps of $10^{o}C$ (30 minutes per step) until $+25^{o}C$ was reached. The electrical tests were performed at the end of each 30 minute step.

f. The temperature was maintained at $+25^{o}C$ for four hours. The electrical tests were performed at the end of this period.

6.1.2. <u>Vibration Test</u>. The vibration test program consisted of the following steps.

a. The distortion and efficiency tests (See Section 6.1.3) were performed prior to mounting the controller and amplifier on the vibration table.

b. The controller and amplifier were mounted on the vertical vibration table. A resonance search was made in the 5 to 500 Hz region. Any resonances found were dwelled on for 30 minutes at the amplitudes specified by the following table:

Frequency Range (Hz)	D.A. (inches)	Acceleration -G's
5-12	.2 *	---
12-26	---	1.3
26-52	.036	---
52-500	---	5.0

* = limited by capability of the vibration machine

c. The equipment was vibrated at the levels given in step b. above for the time cycles given below. Each time cycle was performed three times.

Frequency Range (Hz)	Cycle Time
5 - 26 - 5	5 min
26 - 52 - 26	5 min
52 - 500 - 52	5 min

d. The equipment was examined visually for mechanical failure.

e. Steps b through d above were repeated for the major and minor horizontal axes.

f. The distortion and efficiency tests were performed at the end of the vibration tests.

6.1.3. Distortion and Efficiency Tests. The electrical test program consisted of the following steps.

a. The test equipment was setup in the manner shown in Figure 6-1.

b. The oscilloscope gain (input to vertical output) was measured by connecting the input to a sinewave source of known RMS output and noting the vertical output level as displayed on the RMS volt meter.

c. The power supply was adjusted for 28V D.C.

d. The gain control on the AN/UIQ-10 was adjusted so that the output was 250 watts. This was calculated from the following formulas:

$$(\text{RMS Voltmeter reading}) \times (\text{scope gain}) = (\text{AN/UIQ-10 Voltage output})$$

$$\frac{(\text{AN/UIQ-10 Voltage output})^2}{(\text{Load Impedance})} = (\text{AN/UIQ-10 power output})$$

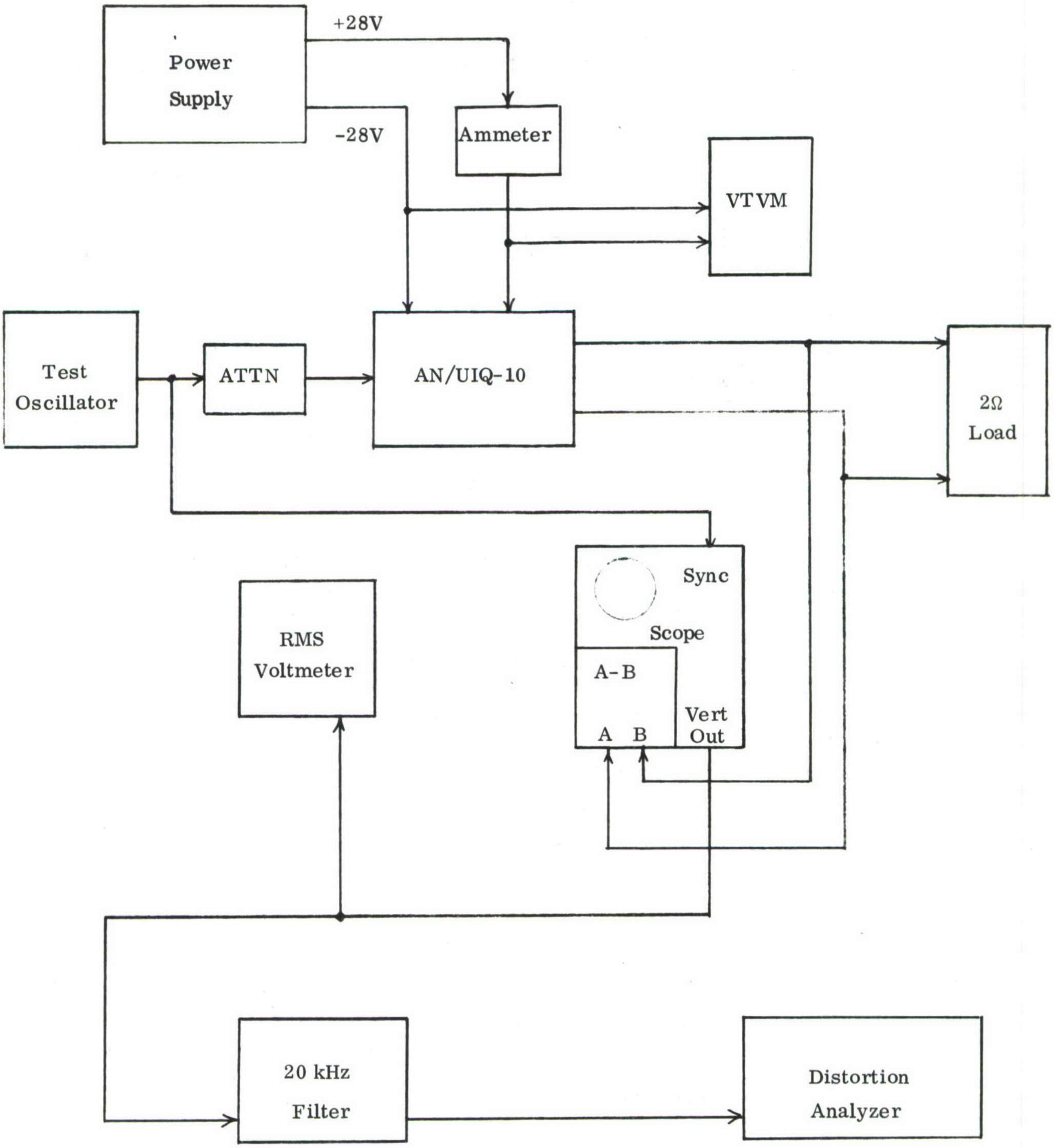

Figure 6-1. Test Set-up for Distortion and Efficiency Tests

e. The distortion, in percent, was read from the distortion analyzer.

f. The efficiency was calculated using the following formulas:

$$\text{(AN/UIQ-10 Power input)} = \text{(AN/UIQ-10 Voltage input)} \times \text{(AN/UIQ-10 Current input)}$$

$$\text{Efficiency} = \frac{\text{(AN/UIQ-10 Power output)}}{\text{(AN/UIQ-10 Power input)}}$$

6.2. TEST RESULTS.

6.2.1. Temperature Tests. The results of the distortion and efficiency tests performed during the temperature cycling are shown on the attached data sheets. The primary results were:

a. Problems were encountered with the operation of the temperature chamber at $-40^{\circ}C$ and at $+65^{\circ}C$. All of these problems were solved by manual operation of the chamber controls.

b. A problem of increased distortion was noted at $+30^{\circ}C$ and $+40^{\circ}C$. This was traced to a loose connection on the audio input cable ground external to the UIQ-10. This was repaired and testing resumed with no further difficulties.

6.2.2. Vibration Tests. The results of the vibration testing and the electrical tests performed before and after the vibration test are shown in the attached data sheets. The primary results were:

a. The amplifier box failed the vibration test due to a crack in the case at the rosette weld for the relay bracket. This was due in part to the fact that the relay bracket was not flush with the case when the weld was made, resulting in the bracket and relay oscillating on the two pillars of weld material.

b. The relay bracket was redesigned, a stiffener plate was added, both were spot welded, and the vibration test repeated with no mechanical failure.

c. After the vibration tests the AN/UIQ-10 was found to operate only intermittently. This was traced to a transistor (Q7 in the amplifier, 2N3253) which had apparently suffered a random failure as a result of the vibration. This transistor was replaced and the electrical (distortion and efficiency) test repeated with the AN/UIQ-10 performing satisfactorily.

TEMPERATURE TEST DATA SHEET

Item under test: AN/UIQ-10 S/N P1

Test Conditions: Supply Voltage -28 Vdc, Audio input frequency -1 kHz, Scope gain conversion factor -13.3, Output Voltage -1.68 Vrms, Output Power - 250 watts,

Test Dates: 2 August through 4 August 1971

Test Personnel: P. Sheridan, F. Tushoph

Time/Day	Temp °C	Current In A	Power In W	Distortion %	Efficiency %	Comments
10:45 am/2	-15	9.4	263	13.0	95.0	Automatic control of temperature failed several times during this period requiring manual override to control temperature
11:30 am	-40	9.22	258	14.6	97.0	
1:00 pm	-43	9.25	259	14.4	96.6	
2:00 pm	-45	9.25	259	14.0	96.6	
3:00 pm	-43	9.25	259	14.0	96.6	
4:00 pm	-43	9.25	259	13.2	96.6	
5:00 pm	-43	9.20	258	13.2	97.0	
7:00 pm	-43	9.20	258	12.5	97.0	
10:00 pm	-41	9.20	258	13.0	97.0	
12:30 am/3	-42	9.30	260	14.0	96.0	
2:30 am	-42	9.35	262	14.0	95.5	
6:00 am	-42	9.30	260	13.5	96.0	
8:00 am	-42	9.30	260	13.5	96.0	
10:45 am	-40	9.30	260	13.5	96.0	
11:22 am	-30	9.30	260	14.0	96.0	
11:52 am	-20	9.30	260	13.2	96.0	
12:22 pm	-10	9.35	262	12.8	95.6	
12:52 pm	0	9.40	263	12.0	95.0	
1:22 pm	+10	9.40	263	11.7	95.0	
1:52 pm	+20	9.45	264	11.2	94.5	
2:22 pm	+30	9.50	266	18 to 26	94.0	Erratic distortion of waveform traced to loose connection.
3:10 pm	+40	9.45	264	18 to 26	94.5	
4:12 pm	+30	9.45	264	10.2	94.5	
5:00 pm	+40	9.45	264	9.5	94.5	
5:40 pm	+50	9.40	263	8.5	95.0	
6:15 pm	+60	9.45	264	9.0	94.5	
6:45 pm	+65	9.40	263	8.5	95.0	
10:15 pm/3	+65	9.40	263	8.5	95.0	
10:45 pm	+55	9.60	269	10.0	93.0	
11:15 pm	+45	9.60	269	10.5	93.0	
11:45 pm	+35	9.70	271	12.0	92.2	
12:05 am/4	+25	9.90	277	14.0	90.3	
12:15 am	+25	9.90	277	14.0	90.3	
7:30 am	+25	10.00	280	14.0	89.3	End of temperature testing

VIBRATION TEST DATA SHEET

(Mechanical Results)

Item under test: AN/UIQ-10 Amplifier S/N P1 (unmodified)

Test Date: 5 August 1971

Test Personnel: P. Sheridan, F. Tushoph

RESONANCE SURVEY

Axis of Vibration	Resonances found (Hz), Mechanical Results
Minor Horizontal	63.5, 127, 254, Serious "oil-canning" of case over relay bracket, especially at 127 Hz.
Vertical	125, 250, Again serious "oil-canning" of case over relay bracket at 125 Hz. Circular crack forming around rosette weld. Test halted at this point.
Major Horizontal	Not performed

VIBRATION TEST DATA SHEET

(Mechanical Results)

Item under Test: AN/UIQ-10 Amplifier S/N P1 with stiffener plate and larger relay mounting bracket

Test Date: 12 August 1971

Test Personnel: F. Tushoph

RESONANCE SURVEY

Axis of Vibration	Resonances found (Hz),	Mechanical Results
Vertical	Broadband Resonance 130 to 350 peak at ~320 Hz	Resonance center located on center of base of case. No visible indication.
Major Horizontal	Broadband Resonance 300 to 500 peak at ~375 Hz	Resonance center located on case over relay bracket. No visible indication.
Minor Horizontal	Broadband Resonance 150 to 190 peak at ~163 Hz	Resonance center located case over relay bracket. Slight "oil-canning" detected.
	273, 327, 365, 405, 457 and 495, largest resonances at 273, 365 and 405	Resonance center located on center of base of case. No visible indication.

VIBRATION TEST DATA SHEET

(Mechanical Results)

Item under test: AN/UIQ-10 Amplifier S/N P1 with stiffener plate and larger relay mounting bracket

Test Date: 12 August 1971

Test Personnel: F. Tushoph

RESONANCE DWELL (1/2 hour at each Resonance)

Axis of Vibration	Resonance Frequency (Hz)	Visual Examination Results
Vertical	320	No visible degradation
Major Horizontal	375	No visible degradation
Minor Horizontal	163	No visible degradation
	273	" " "
	365	" " "
	405	" " "

VIBRATION TEST DATA SHEET

(Mechanical Results)

Item under test: AN/UIQ-10 Controller S/N P1

Test Dates: 5, 6, and 12 August 1971

Test Personnel: F. Tushoph

RESONANCE SURVEY

Axis of Vibration	Resonances found (Hz),	Mechanical Result
Vertical	420	Resonance centered on belt clip
Major Horizontal	390, 475	Resonance centered on belt clip
Minor Horizontal	None	

VIBRATION TEST DATA SHEET

(Mechanical Results)

Item under test: AN/UIQ-10 Controller S/N P1

Test Dates: 5, 6, and 12 August 1971

Test Personnel: F. Tushoph

RESONANCE DWELL (1/2 hour at each resonance)

Axis of Vibration	Resonance Frequency (Hz)	Visual Examination Results
Vertical	420	No visible degradation
Major Horizontal	390	No visible degradation
	475	" " "
Minor Horizontal	None	

VIBRATION TEST DATA SHEET

(Mechanical Results)

Items under test: AN/UIQ-10 Controller and Amplifier, amplifier modified with stiffener plate and larger relay mounting bracket.

Test Date: 12 August 1971

Test Personnel: F. Tushoph

CYCLING VIBRATION (15 minutes total in each frequency range)

Axis of Vibration	Frequency Ranges (Hz)	Mechanical Results
Vertical	5 - 26 - 5	No visible degradation
	26 - 52 - 26	" " "
	52 - 500 - 52	" " "
Major Horizontal	5 - 26 - 5	" " "
	26 - 52 - 26	" " "
	52 - 500 - 52	" " "
Minor Horizontal	5 - 26 - 5	" " "
	26 - 52 - 26	" " "
	52 - 500 - 52	" " "

VIBRATION TEST DATA SHEET

(Electrical Results)

Items under test: AN/UIQ-10 Controller and Amplifier

Test Date: 4 August and 13 August 1971

Test Personnel: F. Tushoph

Relation to Vibration Tests	Date	Current In A	Power In W	Distortion %	Efficiency %	Comments Comments
Before	4 Aug.	10.0	280	14.0	89.3	
After	13 Aug.	9.55	268	15.0	93.5	This test took place after Q7 (2N3253) was replaced to correct an intermittent operating condition

7. TEST EQUIPMENT.

7.1 Temperature Tests. All temperature tests were performed in a Tenny Temperature Chamber, Model T64UF-100-240.

7.2 Vibration Tests. The vibration tests were performed using the following test equipment:

Description	Manufacturer	Model/Type Number
Shaker	Calidyne	177A
Audio Amplifier	Westinghouse	GF
Servo Cycling Oscillator	Line	SCO-100
Control Console	Calidyne	94
Vibra-plane	Allied Research Assoc.	407-C1

7.3 Distortion and Efficiency Tests. The electrical tests were performed using the following test equipment:

Description	Manufacturer	Model/Type Number
Power Supply	Hyperion	HY-SS-26-20
Test Oscillator	Hewlett-Packard	651B
Vacuum Tube Voltmeter	Hewlett-Packard	410B
RMS Voltmeter	Hewlett-Packard	3400A
Distortion Analyzer	Hewlett-Packard	330B
Attenuator	Hewlett-Packard	355D
Load	Ohmite	270-175P-46
Variable Electronic Filter	Spencer-Kennedy Labs	302
Oscilloscope	Tektronix	535A
Oscilloscope Preamplifier	Tektronix	1A2
Volt-ohm-Ammeter	Triplett	630

8. CONCLUSIONS.

The development objectives for Public Address Set AN/UIQ-10(XLW-1) have been met successfully. Limited environmental tests disclosed one minor mechanical defect which has been corrected.

Results of the RFI investigation which was performed by Bendix show that radiation far exceeds MIL-STD-461 requirements. It has been shown that in aircraft installations where adequate shielding can be provided significant reductions in emanations can be accomplisted.

The Marine Corps considers the system sufficiently developed and engineered, and has an adequate set of drawings to go into limited production.

Appendix A

TECHNICAL REPORT

RFI/EMC INVESTIGATION

on

Public Address Set
AN/UIQ-10(XLW-1)

Contract DAAD05-71-C-0371

Prepared by:

Bendix Field Engineering Corporation
9250 Route 108
Columbia, Maryland 21043

Dated: 22 October 1971

ABSTRACT

This investigation determined the degree of interference and explored two methods of suppression. The filter method of suppression was found to be unacceptable. The shielding method met with limited success with certain qualifications.

Shielding and the use of a powerline filter is the recommended approach to achieve a reduction of undesirable emissions.

FOREWORD

This report describes the RFI/EMC investigation performed on the AN/UIQ-10 (XLW-1) Public Address Set. The purpose of this investigation was to identify emissions and sources and evaluate the possible RFI fixes. The conclusions of this investigation are summarized at the end of this report.

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1. ORIGIN AND CHARACTERISTICS OF UNDESIRED EMISSIONS

The design concept of the AN/UIQ-10 employs high speed, high current switching circuitry to achieve the optimum operational efficiency factor, and it is this circuitry which radiates the interference signals. Also, it appears that the high frequencies in the transients are ringing parasitic resonant circuits which further add to the undesired emanations.

For the most part, the emanated spectral distribution remains fixed in frequency, but does varies in field strength as a function of the mode of operation and the number of external leads connected to the amplifier. That is; with all speaker leads disconnected, the mass of emanations between 10 and 30 MHz are eliminated, but the spurious or parasitic signals remain unchanged. In addition to the prototype, two other amplifier units were tested and also found to contain the parasitic emanations.

2. TEST CONFIGURATION AND ANALYSIS

A test configuration baseline was established which consisted of the amplifier case being electrically connected to a table ground plane within a RFI shielded room with the power and speaker leads remoted to the outside. This configuration was devised to determine the measurable ability of the case to contain emanations if the shielding integrity is not violated with external leads acting as antennas. Also, this configuration would be representative of the maximum radiation suppression to be expected by filter or shielding modification techniques. The tests were conducted in accordance with MIL-STD-461 and revealed emanations with strength in excess of the radiated emission limits. This indicated that no amount of shielding or filtering of the present AN/UIQ-10 design will be sufficient to meet the radiated emission limits of MIL-STD-461.

3. MIL-STD-461 COMPLIANCE MEASUREMENT RESULTS

Radiated and conducted measurements were performed in accordance with the requirements of MIL-STD-461, and the results are illustrated in figures 1 through 5.

Figure 1 is representative of the emissions to be encountered in a typical field application. While this test was being performed, a comparison of emission amplitudes was made between the conditions of grounding and ungrounding the amplifier with a single contact to a ground rod. The difference in either condition was small or none. Therefore, the data is presented for only the grounded case because it is also representative of the ungrounded emission levels. The purpose of this test was two fold; determine the effect of grounding on the radiated emissions (as mentioned above), and provide baseline data to evaluate the shielding room test environment effect on the radiated measurement accuracy.

Figure 2 shows the measurement results of a set-up similar to that used for figure 1 except for being located in a shielding room. Comparison of the same frequency regions as illustrated in figures 1 and 2 reveal approximately equivalent results indicating the shielded room effect is noticeable, but not excessive.

Figure 3 indicates the measured levels of emissions after completion of all the shielding applications that could logically be used with the existing amplifier housing design. This data is the proof that no fix to the existing housing will reduce the emissions to a level which would be compliant with MIL-STD-461.

Figures 4 and 5 are results of the powerline conducted interference measurements. In comparison with the previous measurements, these results, which are in excess of MIL-STD-461 limits, were expected. Levels of these magnitudes will require considerable suppression before this system can share a power source with any other electronic equipment.

Other radiated measurements using probes and antennas were made with various modifications of the test set-up. These measurements indicated:

a. Each line (control cable, power cable, and speaker lines) contributes to the radiated interference problem.

b. With all lines shielded, the radiation is still present and is emanating from the amplifier box ends containing the cable connectors.

c. The exposed collectors of the four power transistors are not a source of radiated leakage.

d. Shields for the cables would also radiate unless they are continuously connected to the ground plane.

4. RADIATED EMISSION ANALYSIS

Figure 6 through 13 are spectrum analyzer photographs displaying radiated emissions. While the spectrum presented consists of 15 to 385 MHz, the test antenna used with the analyzer for these measurements has a calibrated response for only the 20 to 200 MHz range. However; this fact does not significantly affect the intent of these measurements which is to graphically illustrate, for purposes of comparison, each cables contribution to the total radiated interference.

5. SUPPRESSION METHODS AND ANALYSIS

Test results to this point suggest two possible RFI fix methods; i.e., filter or shielding suppression. The following describes the results of an application of both methods.

a. Filter Suppression Investigation:

Current probe tests indicated that the maximum emissions were from the cable between the amplifier and the control box. Emissions were also measured directly from the amplifier and from the speaker leads; but the relative levels were 20 to 30 dB greater from the control box cable when being measured with a loop probe. This condition was later established as the baseline and used to justify current probe measurements on this cable as being representative of any RFI fixes.

The initial attempt to control the emissions was based on an approach of completely isolating the switching circuits. Filters were placed in the B+ and B- leads, output speaker leads, and driver input (audio into the switch circuity) leads; in addition, the B- lead was separated from chassis ground. The filters in the output speaker leads caused a mismatch in the switch timing and resulted in generating stronger emissions. The filters in the audio input leads caused an unbalance in the switch circuit and resulted in a quiescent current in excess of four amperes. There were no changes in the emission level, either conducted or radiated, with or without the filters in the B+ and B- leads. Similarly, isolation of the B- leads from chassis ground resulted in no difference as compared to grounding the B leads.

Since attempts to isolate the switching circuits failed, an attempt was made to decrease the radiation from one of the prime sources, the control cable between the amplifier and control box. It should be noted that all testing had been performed with the entire AN/UIQ-10 isolated from ground. To decrease the emissions from the cable, an attempt was made to create a pseudo ground at the input to the amplifier; that is, referencing the RFI to this point and isolating the cable from RFI currents. This attempt failed because the reference was necessarily the amplifier chassis, and the chassis was an emitter in itself. It was noted that when the chassis was connected to the test groundplane, the control cable ceased to be an emitter. However, it was also noted, that as long as the chassis was grounded, there was no difference with or without the filters in the control cable leads.

b. Shield Suppression Investigation:

Figure 6 depicts the best emission suppression results which can be expected with the existing design using shielding techniques. Note the 165 MHz parasitic; this emission, together with a 330 MHz parasitic, can be seen in most of the other photographs.

Figure 7 is an indication of the system emissions in a configuration that would normally be used in field applications and in general, illustrates a typical worse-case condition.

Figures 8, 9, 10, and 11 are all variations of the completely shielded test configuration used in figure 6. These modified set-ups prove that each external lead does contribute to the total radiated interference.

Figure 12 provides a more detailed amplitude versus frequency analysis of the parasitic at 165 MHz. The parasitic at 330 MHz is also distributed across several MHz and is almost identical to the 165 MHz emission.

In order to approach meeting MIL-STD 461 requirements, the amplifier, control box, and speaker drivers would require significant changes in housing and connector hardware. These changes should be directed toward attaining an unbroken continuous shield to and between these components. This would involve r-f gasketing all access plates, removal of speaker binding posts, shielded connectors and cables for all interconnecting leads, r-f tight connector caps for connectors not used, a powerline filter box to permit operation from a battery supplying other electronic equipment, and special housing on the speaker drivers to assure shielding continuity.

6. CONCLUSIONS

Filtering as a practical fix is ruled out. The results of the completely shielded test set-up, while not meeting MIL-STD-461 requirements, did provide significant reductions in the radiated emanations. These reductions, are approximately 40 dB in the 0.1 to 1 MHz region and 10 to 30 dB in the 10 to 100 MHz region. These levels of reduction are the best that could be expected if a thorough shielding of all interconnecting cables were the only fix applied to the existing design.

In order to achieve these idealized results, the following must be considered:

a. Some degradation in shielding efficiency will occur at the connections to the speaker drivers.

b. The efficiency of any fix will be destroyed if wires are connected to the amplifier binding posts.

c. The shielding fix will not prohibit the conducted interference that will occur if the amplifier shares a battery that is supplying other electronic equipment - a powerline filter box must be used.

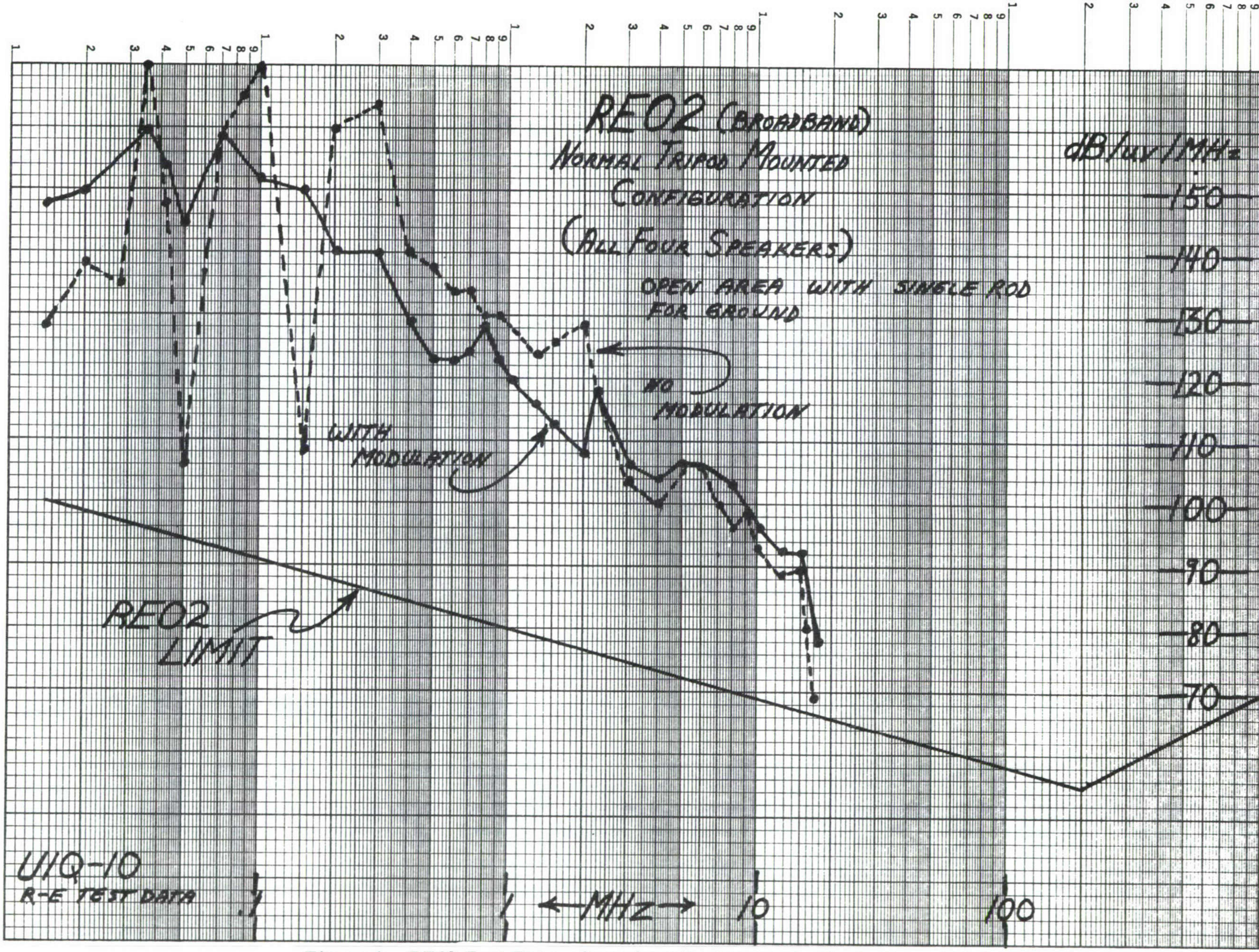

Figure 1. RE02 Test Data - Open Area Environment, Single Ground Rod

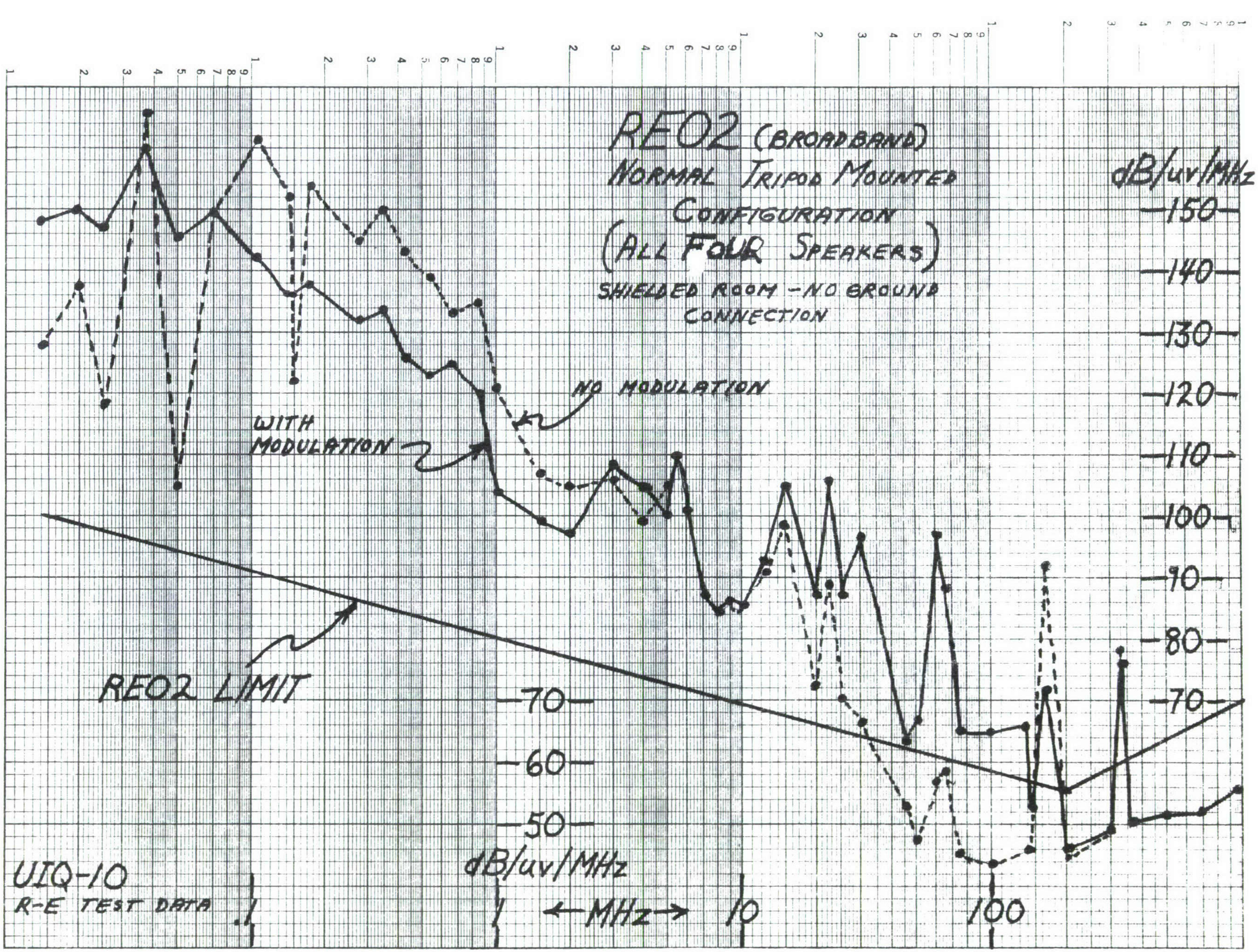

Figure 2. RE02 Test Data - Shielded Room Environment, No Ground Connection

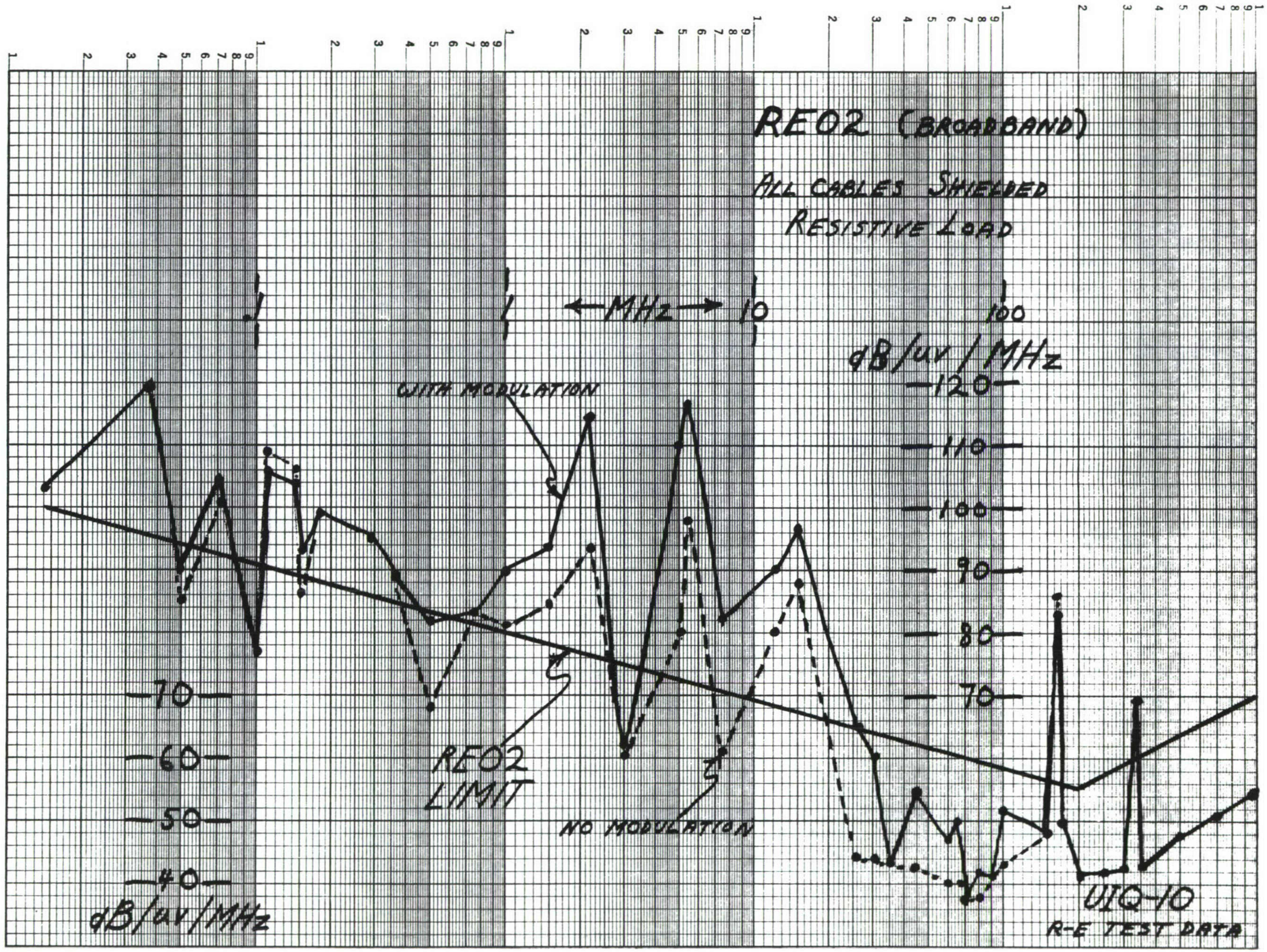

Figure 3. RE02 Test Data - All Cables Shielded

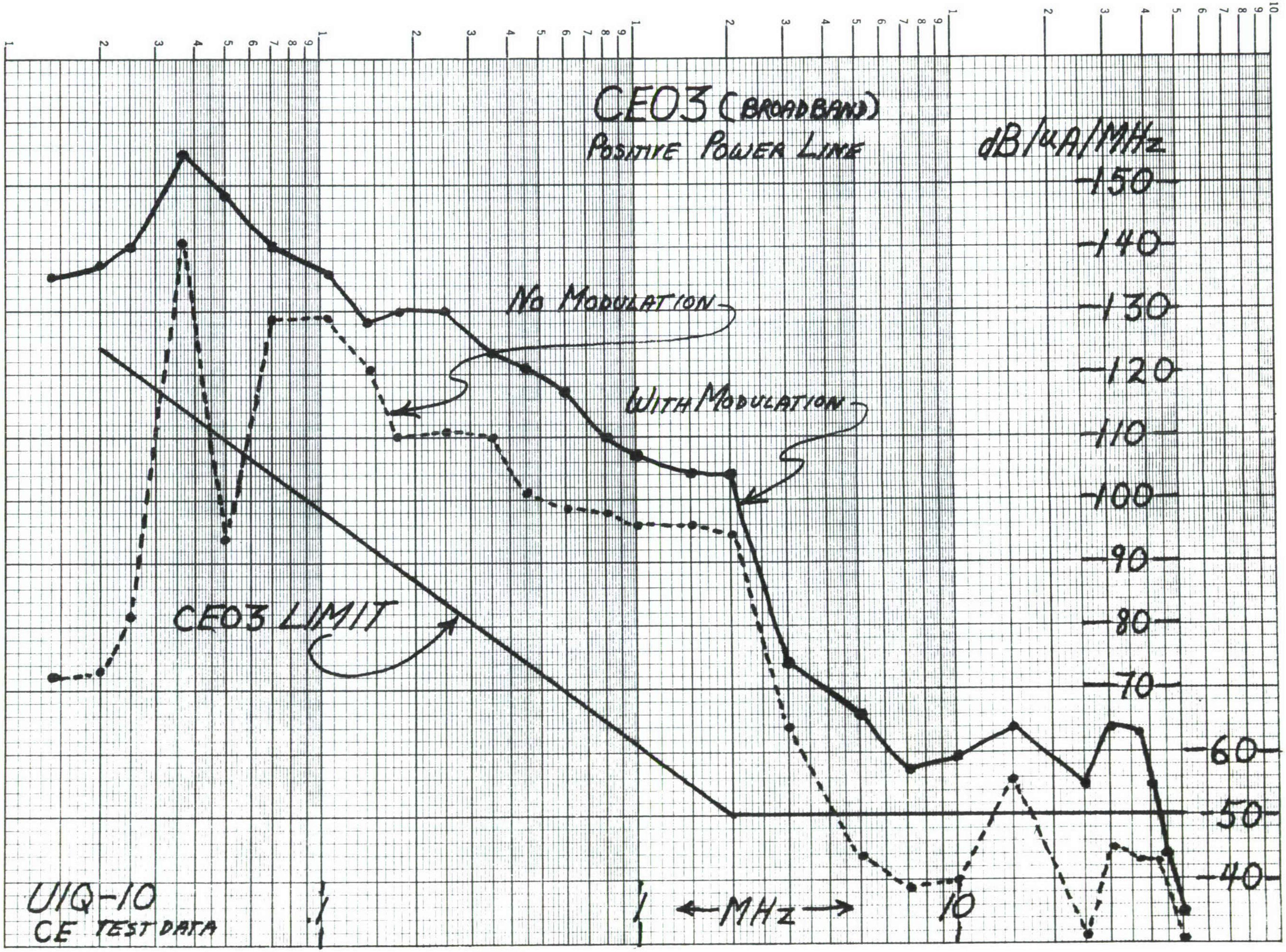

Figure 4. CE03 Test Data - Positive Power Line

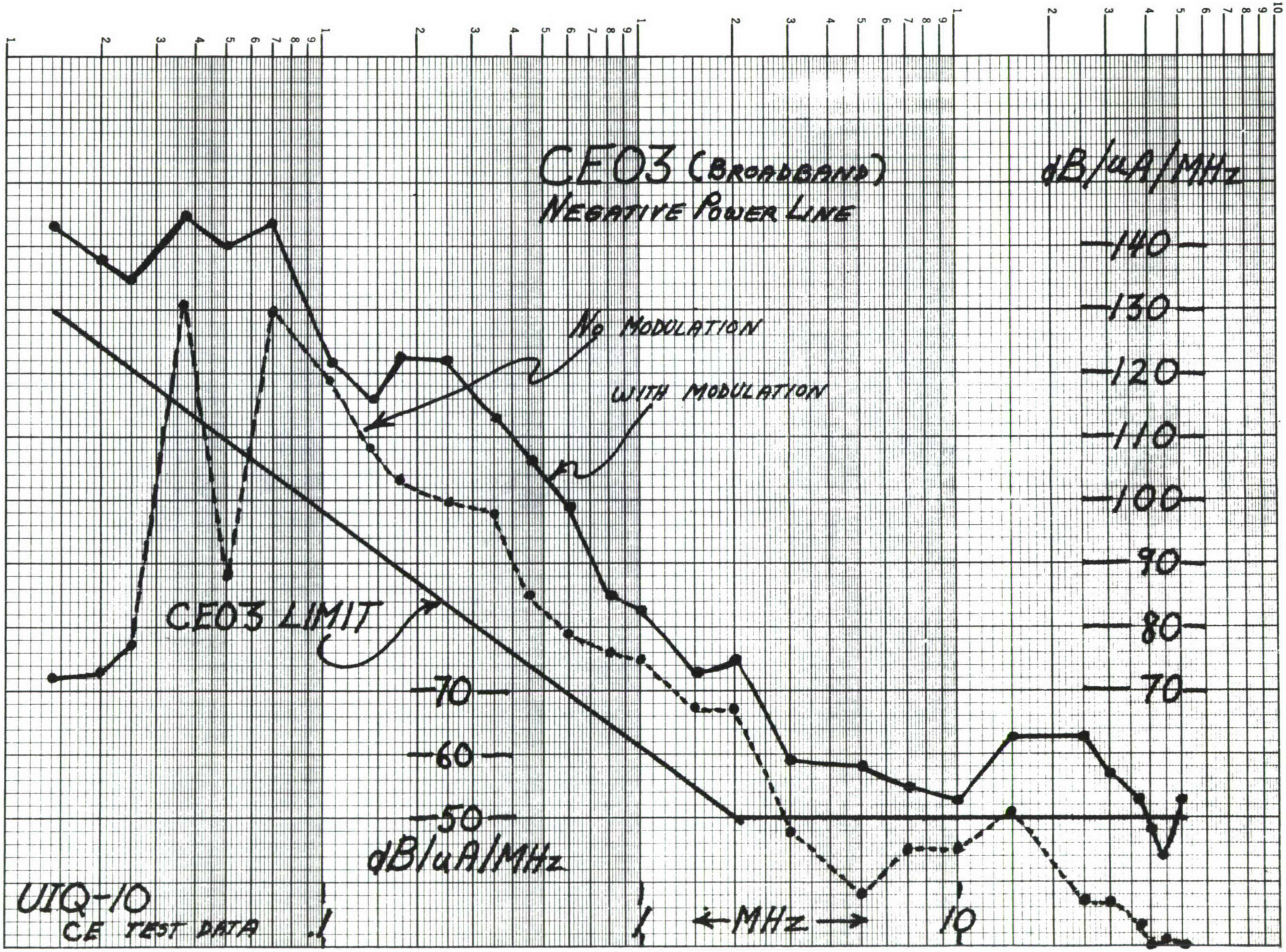

Figure 5. CE03 Test Data - Negative Power Line

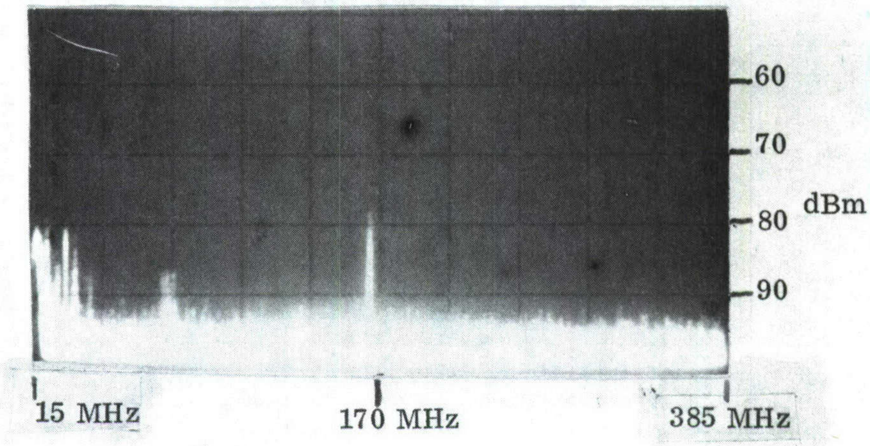

Figure 6 - All Cables and Load Shielded

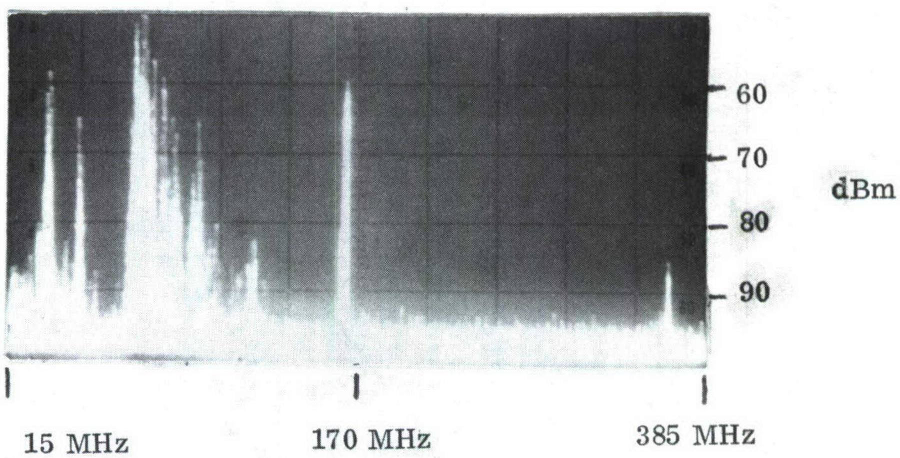

Figure 7 - Normal Tripod 4-Speaker Configuration

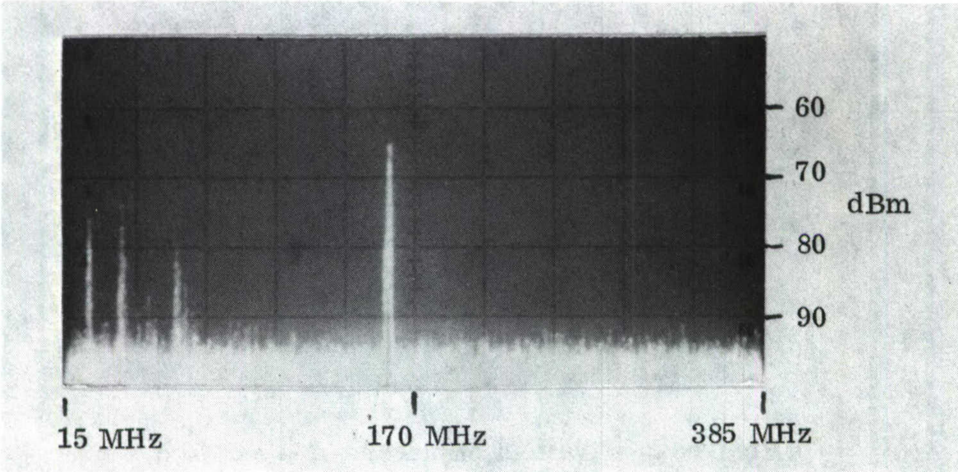

Figure 8 - One speaker connected with
9-inch lead. All other lines & load shielded.

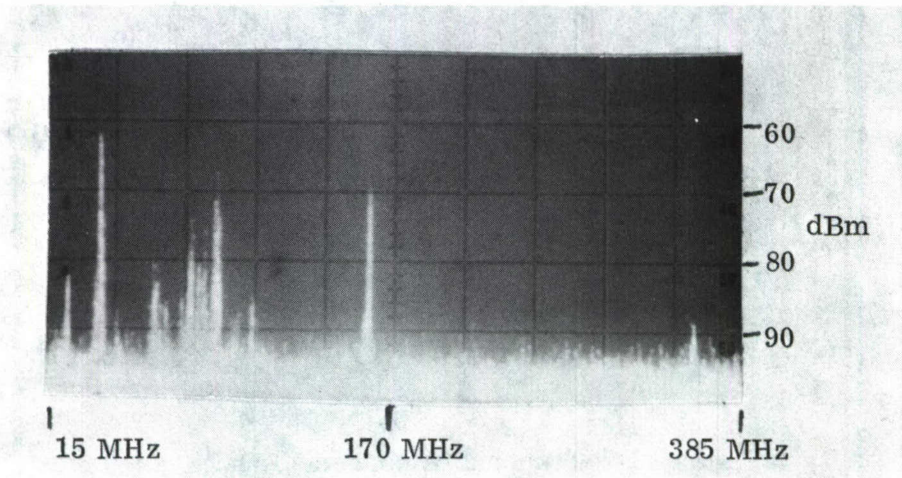

Figure 9 - Five feet of control cable exposed.
All other lines and load shielded.

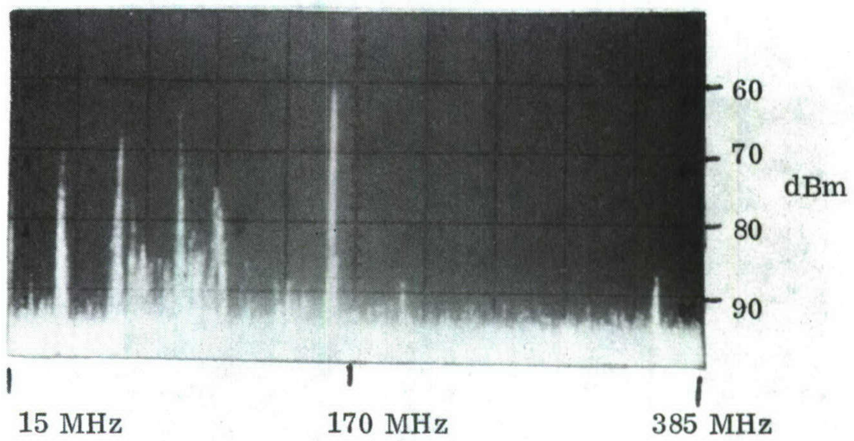

Figure 10 - Five feet of power cable exposed.
All other lines and load shielded.

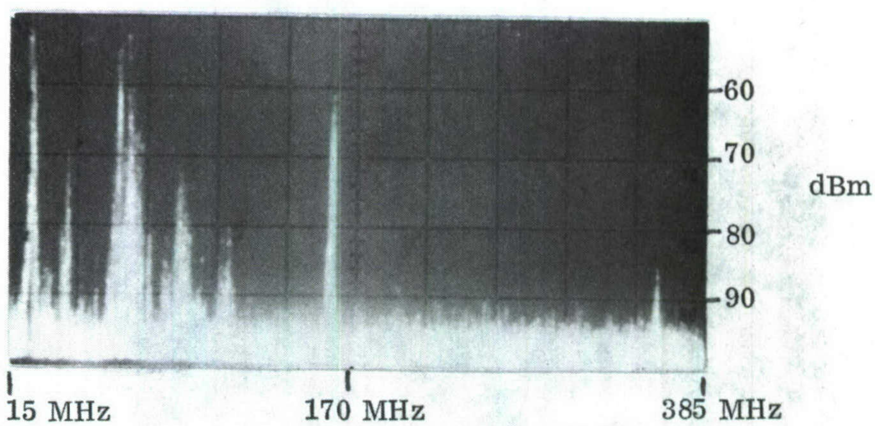

Figure 11- All speakers connected and lines
exposed. All other lines shielded.

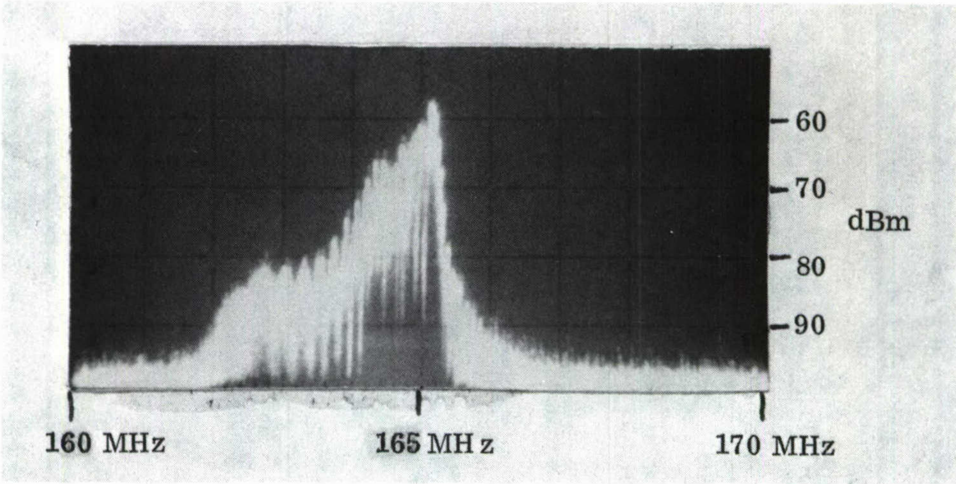

Figure 12- Parasitic Emission detail

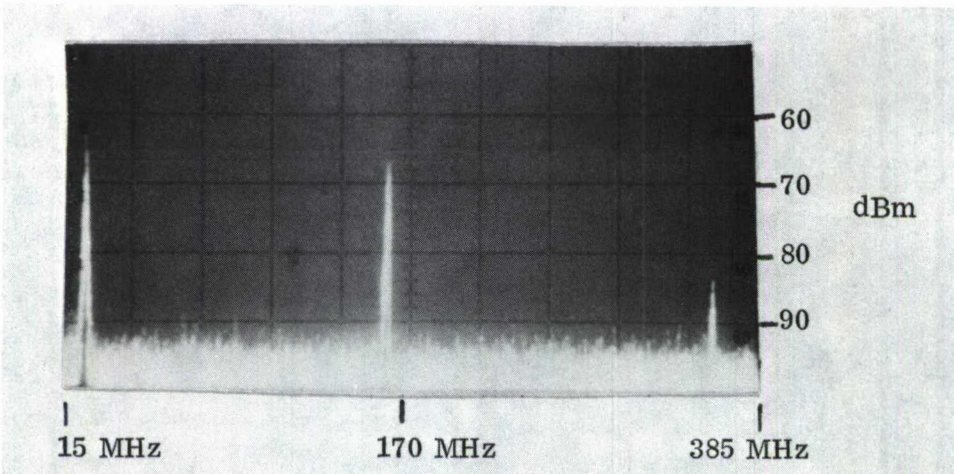

Figure 13- Speaker leads only exposed.
All other lines shielded.
No modulation.

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13. ABSTRACT

This report covers the development of the Public Address Set AN/UIQ-10(XLW-1) under Contract DAAD05-70-C-0252 with the Bendix Field Engineering Corporation. The report also describes the functioning, the characteristics, and the outcome of the various tests performed on the equipment after its development.